

# **Component Testing System**

## **Vacuum Ring and Test Plate Construction**

### **BACKGROUND OF THE INVENTION**

#### **1. Technical Field**

[01.00] This invention relates generally to the batch processing of miniature electronic circuit components, including passive, two-terminal, ceramic capacitors, resistors, inductors, and the like. More particularly, it concerns a vacuum ring and a test plate that are used on a component testing system for holding such components or other type of device under test (DUT) as part of the batch processing for purposes of parametric testing.

#### **2. Description of Related Art**

[02.00] The tiny size of electronic circuit components of interest herein complicates processing. Typically fabricated of ceramic material in parallelepiped shapes having dimensions as small as 0.020" by 0.010" by 0.010" more or less, these difficult-to-handle components require appropriate equipment and precision handling techniques. During testing, such a component is sometimes referred to as a device under test (DUT).

[03.00] U.S. Patent 6,194,679 describes a testing machine for such DUTs. The testing machine in that patent is similar in some respects

1 to the testing machine available from Electro Scientific Industries, Inc. (ESI) of Portland, Oregon as its model ESI-3300. Among other things, the testing machine includes a component-holding part that is referred to herein as a "test plate" and a vacuum-communicating part that is  
5 referred to herein as a "vacuum ring." The test plate is mounted rotatably over the vacuum ring where it functions as means for receiving and hold a batch of DUTs. The vacuum ring (sometimes called a vacuum plate) couples a vacuum to the test plate that helps hold the test plate and load the DUTs onto the test plate. As the test  
10 plate rotates relative to the vacuum ring, various test are performed. After testing, DUTs are blown out of the test plate into various containers according to the test results.

[04.00] Although effective in many respects, there are some concerns  
15 related to the vacuum ring and the test plate. One is wear. Ceramic powder and loose ceramic pieces from DUTs can abrade the surface of the vacuum ring that faces the test plate. The vacuum ring, typically fabricated of nickel-plated steel, must eventually be replaced as a result (as much as two or three times a year).

20 [05.00] In addition, testing may involve voltages on the order of 1000 volts. Various forms of grease, grime, dirt, dust and other electrically conductive material on the vacuum ring and/or on the insulation material around the lower contact provide unwanted  
25 conductive paths. Arc-overs occur, and repeated arc-overs can damage the vacuum ring and even the expensive power supplies.

1 [06.00] DUT size differences introduce another concern. The vacuum  
ring includes what are referred to as eject holes or blow holes that are  
formed in the vacuum ring by milling, drilling, or other mechanical  
process. Compressed air coupled to an eject hole at just the right time  
5 serves to blow a DUT from the test plate into a sorting box according  
to test results. But, different size DUTs require different pressure (i.e.,  
blowout force). Little DUTs require little eject holes for less blowout  
force while bigger DUTs require bigger eject holes for greater blowout  
force. As a result, various vacuum rings must be kept available and  
10 substituted on the test machine according to DUT size.

[07.00] Each of these concerns adds time and expense to DUT testing.  
Thus, a need exists for an improved vacuum ring and test plate  
construction so that the vacuum ring is more abrasion resistant, the  
15 vacuum ring is more arc-over proof, and differing DUT sizes are better  
accommodated.

## SUMMARY OF THE INVENTION

20 [08.00] This invention addresses the concerns outlined above by  
providing a vacuum ring and test plate construction such that the  
vacuum ring and test plate include a base material (e.g., aluminum) and  
ceramic layer (e.g., alumina) covering the surface of the base material.  
25 The ceramic layer is hard and more abrasion resistant. It is also  
electrically non-conductive and more arc-over proof.

1 [09.00] In addition, one embodiment of the vacuum ring includes an  
eject hole that better accommodates different DUT sizes. The eject  
hole is actually a pattern of tiny laser-machined holes such that littler  
DUTs cover or occlude fewer holes for less blowout force while  
5 bigger DUTs cover more holes for greater blowout force (i.e., ejection  
force).

[10.00] To paraphrase some of the more precise language appearing  
in the claims and further introduce the nomenclature used, a vacuum  
10 ring for use in conjunction with a test plate on a component testing  
system includes a metallic base material that defines at least one  
vacuum-communicating passageway. The metallic base material has  
a test-plate-facing first surface and means are provided for improving  
abrasion resistance of the vacuum ring. For that purpose, a ceramic  
15 layer is disposed on the test-plate-facing first surface of the metallic  
base material.

[11.00] In one embodiment, the metallic base material is composed of  
aluminum and the ceramic layer is composed of alumina that is usually  
20 no less than 20 micrometers thick and no greater than about  
100 micrometers thick. Preferably, the ceramic layer is bonded to the  
metallic base material by molecular adhesion using a micro-arc  
oxidation process.

25 [12.00] A test plate constructed according to another aspect of the  
invention for holding DUTs includes a DUT-holding structure that

1 defines at least one DUT-receiving hole. The DUT-holding structure is  
composed at least partially of a metallic material that has oppositely  
facing first and second outer surfaces. A ceramic layer disposed on at  
least the first outer surface of the DUT-holding structure improves  
5 abrasion resistance of the test plate. In one embodiment, the  
DUT-holding structure includes an internal wall that defines the  
DUT-holding hole and the ceramic layer (electrically nonconductive)  
covers both the first and second surfaces and the internal wall in order  
to enable use of the DUT-holding structure as a guard layer that is held  
10 at a selected electrical potential for testing purposes.

[13.00] According to yet another aspect of the invention, there is  
provided a vacuum ring for use in conjunction with a test plate on a  
component testing system for testing DUTs. The vacuum ring includes  
15 a base with an eject hole pattern for discharging compressed gas  
toward the DUTs in order to eject DUTs from the test plate. Each DUT  
has a cross sectional area less than a predetermined minimum cross  
sectional area and the eject hole pattern is sized accordingly. The eject  
hole pattern includes a plurality of closely spaced apart individual holes  
20 such that each of the individual holes has a cross sectional area that  
is somewhat less than the size that would be large enough to receive  
a DUT having the predetermined minimum cross sectional area. With  
that arrangement, the number of holes affecting a particular DUT for  
DUT ejection purposes is dependent on the cross sectional size of that  
25 particular DUT. The holes may take any of various forms, including  
being circular, oval, or elongate slots.

1 [14.00] Thus, the invention provides an improved vacuum ring and test  
plate construction such that the vacuum ring and test plate are more  
abrasion resistant, the vacuum ring is more arc-over proof, and differing  
DUT sizes are better accommodated. The following illustrative  
5 drawings and detailed description make the foregoing and other objects,  
features, and advantages of the invention more apparent.

#### BRIEF DESCRIPTION OF THE DRAWINGS

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[15.00] FIG. 1 of the drawings is an exploded up view of some parts  
of a component testing machine, including a vacuum ring and a test  
plate that are constructed according to the invention;

15 [16.00] FIG. 2 is a cross sectional elevation view of a portion of the  
vacuum ring as viewed in a vertical plane containing a line 2-2 in  
FIG. 1;

[17.00] FIG. 3 is a cross sectional elevation view of a portion of the  
20 test plate as viewed in a vertical plane containing a line 3-3 in FIG. 1;

[18.00] FIG. 4 is a top plan view of an eject hole portion of the vacuum  
ring showing an eject hole pattern according to the invention;

25 [19.00] FIG. 5 is an isometric view of a typical DUT to be tested;

1 [20.00] FIG. 6 is a cross sectional elevation view of the eject hole  
portion as viewed in a vertical plane containing a line 6-6 in FIG. 4;

[21.00] FIG. 7 is an enlarged diagrammatic representation of the eject  
5 hole pattern with two DUT sizes superimposed; and

[22.00] FIG. 8 is top plan view of another eject hole portion that  
combines circular holes and oblong holes.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

[23.00] FIG. 1 of the drawings shows a component testing system 10  
that includes a vacuum ring 11 (a vacuum-communicating part) and a  
15 test plate 12 (a component-holding part) that are constructed according  
to the invention. The testing system 10 is similar in some respects to  
the testing machine described in U.S. Patent 6,194,679 and the testing  
machine in that patent is similar in some respects to the testing  
machine available from Electro Scientific Industries, Inc. (ESI) of  
20 Portland, Oregon as its model ESI-3300.

[24.00] The component testing system 10 includes what is sometimes  
called a base plate 13 on which the vacuum ring 11 is mounted. The  
test plate 12 mounts rotatably over the vacuum ring 11 where it  
25 functions as means for receiving and hold a batch of DUTs. The

1 vacuum ring **11** operates in conjunction with the test plate **12** in a known way to couple a vacuum source (not shown) on the component testing system **10** to the test plate **12** and DUT-holding holes in the test plate **12**.

5 [25.00] Thus, the vacuum ring **11** couples a vacuum to the test plate **12** that helps hold the test plate **12** and helps load the DUTs onto the test plate **12**. As the test plate **12** rotates relative to the vacuum ring **11**, various test are performed. For that purpose, upper and lower  
10 contactor assemblies **14** and **15** operate to electrically contact terminals on DUTs held in DUT-holding holes as the test plate **12** rotates.

[26.00] After testing, DUTs are blown out of the test plate **12** into various containers (not shown) according to the test results. However,  
15 as the test plate **12** rotates relative to the vacuum ring **11**, ceramic dust and particles from DUTs move across the vacuum ring **11** in an abrasive manner. The test plate **12** is similarly affected and so the abrasion resistance provided by this invention is desirable in order to limit replacement requirement.

20 [27.00] To achieve the desired abrasion resistance, the vacuum ring **11** includes a metallic base material **16** (e.g., aluminum) on which a ceramic layer **17** (e.g., alumina) is disposed (FIG. 2). The base material includes a test-plate-facing first surface **16A** and an opposite second  
25 surface **16B**. In operation, the first surface **16A** faces upwardly toward

1 the test plate **12** while the second surface **16B** faces downwardly away  
from the test plate **12**.

5 [28.00] To function as a vacuum ring, the base material **16** defines at  
least one vacuum-communicating passageway **18**. The ceramic layer **17**  
is disposed on the test-plate-facing first surface **16A** so that the  
vacuum-communicating passageway **18** is exposed. So disposed, the  
ceramic layer **17** functions as means for improving abrasion resistance  
10 of the vacuum ring **11** by improving abrasion resistance of the first  
surface **16A**. Of course, the second surface **16B** (and other parts of  
the vacuum ring **11**) can also coated with a ceramic layer (not shown)  
for even more wear resistance and for convenience of fabrication.

15 [29.00] FIG. 2 is not drawn to scale. The thickness of the base  
material **16** and the thickness of the ceramic layer are exaggerated for  
illustrative purposes. However, the thickness of the illustrated base  
material **16** is about one-eighth inch while the thickness of the ceramic  
layer **17** fall is the a range of about 20 micrometers to about  
100 micrometers.

20 [30.00] Preferably, the ceramic layer **13** is bonded to the metallic base  
material **16** by molecular adhesion. For that purpose, the illustrated  
ceramic layer **17** is formed on the metallic base material **16** by a known  
micro-arc oxidation process. The base material **16** is immersed in an  
25 electrolytic bath (water and highly dilute electrolyte) after which an  
electric current is applied to generate a series of micro-arcs on the

1 surface of the object that result in oxidation by micro-arcs. The micro-  
arcs pierce the layer of hydrated oxides covering the object, and the  
holes produced are then filled by the formation of a hard, ceramic-type  
oxide (the ceramic layer 17) which, in the case of aluminum, is  
5 composed mainly of crystalline aluminum (i.e., alumina).

[31.00] The electrical process described above grows a somewhat  
thick, high quality ceramic layer 17 (on the order of 20 to 100  
micrometers thick) on the base material 16. Unlike the chrome and  
10 nickel plating processes, no metal is added, and there is no waste liquid  
to be processed. Furthermore, the coating is more robust than others,  
because the hard outer layer (i.e., the ceramic layer 17) is bonded to  
the aluminum (the base material 16) by molecular adhesion. Further  
details of the above process are available from Mofratech Company of  
15 Seynod, France under the trademark ALTIM TD. The process can also  
be used on titanium and magnesium.

[32.00] Turning now to FIG. 3, it shows further details of the test  
plate 12. The test plate 12 includes a DUT-holding structure 20 that  
20 defines at least one DUT-receiving hole 21. The DUT-holding  
structure 20 (a base) is composed of a metallic material (e.g.,  
aluminum) that has oppositely facing first and second outer  
surfaces 20A and 20B. The DUT-holding structure 20 could be  
multilayered so long as the first and second outer surfaces 20A  
25 and 20B are metallic.

1   **[33.00]**   In a manner somewhat similar to that of the vacuum ring **11**  
described above, the test plate **12** includes means for improving  
abrasion resistance of the test plate in the form of a ceramic layer (e.g.,  
alumina) having at least a first ceramic layer portion **22** that is disposed  
5   on the first outer surface **20A** of the DUT-holding structure **20**.  
Preferably, the first ceramic layer portion **22** is bonded to the first outer  
surface **20A** by molecular adhesion using the micro-arc oxidation  
process described above for the vacuum ring **11** with the result that the  
ceramic layer portion **22** has a thickness in the range of 20 micrometers  
10   to 100 micrometers.

**[34.00]**   In addition, the test plate **12** includes an internal wall **20C** that  
defines the DUT-holding hole **21**. The ceramic layer includes a  
hole-covering second ceramic layer portion **23** that covers the internal  
15   wall **22C**. Similarly, a third ceramic layer portion **24** covers the second  
outer surface **20B**. That arrangement enables use of the the  
DUT-holding structure **20** as a guard layer that is held at a selected  
electrical potential for testing purposes, with the ceramic layer  
portions **22**, **23**, and **24** providing an electrically nonconductive  
20   layer. For further details of a test plate with one or more guard layers,  
refer to United States Patent Application 20030197500 published  
October 23, 2003.

**[35.00]**   FIGS. **4**, **5**, and **6** show details of a vacuum ring **30** constructed  
25   according to the eject-hole aspect of the invention. The vacuum ring **30**

1 may be similar in many respects to the vacuum ring **11** described above,  
and the drawings are not to scale. The vacuum ring **30** is used in  
conjunction with a test plate on a component testing system (not shown  
in FIGS. **4-6**) for testing DUTs (e.g., the DUT **31** in FIG. **5**).

5 [36.00] The vacuum ring **30** includes a base **32** with an eject hole  
pattern **33** for discharging compressed gas toward the DUTs in order  
to eject DUTs from the test plate. Each DUT to be held by the test  
plate has a cross sectional area and the eject hole pattern **33** is sized  
10 accordingly. The cross sectional area of the DUT **31** is identified in  
FIG. **5** by reference numeral **34** to indicate that to which "predetermined  
cross sectional area" refers. The DUT **31** is not drawn to scale. It is  
greatly enlarged in FIG. **5** relative to the eject hole pattern **33** for  
illustrative convenience and the DUT terminations are shaded.

15 [37.00] The eject hole pattern **33** includes a plurality of forty-nine  
closely spaced-apart individual holes **35**, only one hole **35** being  
identified in FIGS. **4** and **6** for illustrative convenience. The cross  
sectional area of each DUT to be tested (e.g., typically as small as  
20 0.010" by 0.010") is greater than a predetermined minimum cross  
sectional area, and the hole pattern **33** is such that each of the  
individual holes **35** has a cross sectional area that is somewhat less  
than the predetermined cross sectional area (i.e., somewhat less than  
the size that would be large enough to receive a DUT having the  
25 predetermined minimum cross sectional area). The illustrated individual  
holes **35** are circular, but a hole pattern with holes having any of

1 various other shapes may be used instead, including holes that are oval  
and elongate slots or spaced apart slits laser machined into the  
base 32. An airway 36 that is drilled, milled, or otherwise formed in  
the base 32 of the vacuum ring 30 (FIG. 6) serves to communicate  
5 compressed air to the individual holes 35.

[38.00] In other words, the DUTs to be tested will not fit partially into  
the individual holes 35, and the number of holes a particular DUT  
occludes is dependent on the size of that particular DUT. Stated  
10 another way, the number of individual holes 35 of the hole pattern 33  
that affect a particular DUT for DUT ejection purposes is dependent on  
the cross sectional size of that particular DUT. As a result, the vacuum  
ring 30 works with DUTs having significantly different sizes.

15 [39.00] FIG. 7 illustrates the foregoing. It is an enlarged diagrammatic  
representation of the eject hole pattern 33 with two different sized DUTs  
superimposed. A smaller first DUT 31A (the smaller square) covers  
just one eject hole so that a relatively small blast of air (i.e., ejection  
force) affects it for ejection purposes. A larger second DUT 31B (the  
20 larger square) fully covers nine eject holes and partially covers an  
additional four eject holes so that a relatively large blast of air affects  
it for ejection purposes. FIG. 8 is top plan view of an eject hole  
pattern 40 that combines circular holes and oblong holes.

1   **[40.00]**   Thus, the invention provides an improved vacuum ring and test  
plate construction such that the vacuum ring and test plate are more  
abrasion resistant, the vacuum ring is more arc-over proof, and differing  
DUT sizes are better accommodated.   Although exemplary  
5   embodiments have been shown and described, one of ordinary skill in  
the art may make many changes, modifications, and substitutions  
without necessarily departing from the spirit and scope of the invention.

**[41.00]**   What is claimed is:

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